Relationships between conformation traits and longevity of Holstein cows in the Czech Republic

M. Vacek, M. Štípková, E. Němcová, J. Bouška

Research Institute of Animal Production, Prague-Uhříněves, Czech Republic

ABSTRACT: The relationships between conformation traits and longevity traits were analyzed in 41 489 Holstein cows born in the years 1994–1999 which were culled by 30th June 2005. Pearson correlation coefficients between type traits and the herd life or productive life of cows were calculated. The effects of type trait scoring level on the length of productive life were described by means of analyses of variance. The observed correlations between herd life or productive life and type traits are in the range of –0.061 to 0.160. Negative correlations were found for rump angle, rear leg set, udder depth, and teat length. Most of the body traits had slightly positive relationships to herd life, indicating that larger cows live longer. However, body depth and chest width did not have a linear relation to longevity traits. The longest productive life was found in cows undersized in chest width and body depth ($P < 0.01$). A similar dependence was also found for rump width ($P < 0.01$). The ideal rear leg set for longevity was scored as average or below average, i.e. moderately curved or slightly straight legs ($P < 0.05$). Cows with well-attached fore udder, high attached rear udder, strong central ligament, close front teat placement, and with moderately long teats showed the longest functional productive life ($P < 0.05–0.001$). Linear relationships between longevity traits and general conformation characteristics were found as well.

Keywords: Holstein cows; longevity; type traits; correlations

Longevity is a trait of increasing importance in dairy cow breeding and selection. Longevity has its important economic value within dairy cattle breeding schemes (Essl, 1998). In the literature, various definitions of longevity and many different methods of analysis are used, and results differ greatly. Longevity traits are usually divided into two classes: lifetime and stayability. Lifetime traits are as follows: herd life (HL) – the interval between birth and culling, productive life (PL) or length of productive life – the interval between first calving and culling, total milk production – lifetime milk production summed up over lactations, number of days in lactation – lifetime milking days totalled over lactations, and the number of lactations. Stayability traits usually comprise survival to a certain number of months of age (e.g. 36 or 72 months of age) or stayability to a certain number of months after first calving (e.g. 12, 36 months of PL, etc.), and survival to a certain lactation (Vollema, 1998). Longevity traits can be corrected for milk production, thus aiming to give better measurements of involuntary culling (Dekkers, 1993). Corrected traits are also called "functional" traits (Vollema, 1998).

The study of relationships between animal longevity and other characteristics and traits is of crucial importance and is aimed at the improvement of selection response. In this respect, type traits are particularly important, and linear type classification systems are a part of animal evaluations in most countries with a developed dairy industry (Mark, 2004). Efficient selection for longevity is, however, rather difficult because in a real time it

Supported by the Ministry of Agriculture of the Czech Republic (Project No. NAZV 1G46086).

is not possible to obtain estimated breeding values of sires on the basis of direct longevity of their daughters. Selection can therefore be realized only indirectly through type traits which are correlated to longevity.

According to a number of authors, the relationship between longevity and some type traits is evident. For example, Vollema and Groen (1997) found a non-linear relationship between udder depth, central ligament, teat placement and foot angle. Similar conclusions were reported by Vukasinovic et al. (1994), Cruickshank et al. (2002), Vukasinovic et al. (2002) and Tsuruta et al. (2005). Strapák et al. (2005) and Bouška et al. (2006) confirmed significant correlations between longevity and udder traits.

A possibility of using indirect information to predict the cow's longevity and its breeding value appears to be efficient. The present study brings together relationships between selected linear type traits and longevity of Holstein cows in the Czech Republic.

MATERIAL AND METHODS

Holstein cows born in the years 1994–1999 with their first calvings in 1 685 herds in the period from 1996 to 2002 were included in the data set (n = 47 923). All cows were scored by the classifiers of the Czech and Moravian Breeders Association (CMSCH) for the following linear type traits:

Trait	1 point	9 points
Angularity	Lacks angularity	Very angular
Stature	Short	Tall
Chest width	Narrow	Wide
Body depth	Shallow	Deep
Rump angle	High pins	Extreme slope
Rump width	Narrow	Wide
Rear legs side view (rear legs set)	Straight	Sickled
Foot angle	Very low	Very steep
Fore udder attachment	Weak	Strong
Rear udder height	Low	High
Central ligament	Indistinct	Deep
Udder depth	Deep	Shallow
Front teat placement	Wide	Narrow
Teat length	Short	Long

Four body measurements (withers height, height at sacrum, chest girth, and body length) were also measured. In addition, 5 general characteristics were evaluated and the final score was determined. Dairy character, body capacity, rump, feet and legs, and udder were scored in the range of 50 to 100 points. Production traits (milk yield and fat and protein percentage and yield) in the first lactation, date of first calving and culling were determined. For the analysis of the relationship between type traits and longevity, cows culled by 30th June 2005 (n = 41 489) were used.

Analysed data were corrected in the following way:

(a) Milk yields in kg were adjusted by the equation with fixed effect of Herd-Year-Season of the first calving (HYS) and linear regression on age at the first calving. Afterwards the cows were divided on the basis of adjusted milk yield in the first lactation into three classes (< 5 750 kg; 5 750–6 950 kg; 6 950 kg of milk).

(b) Linear type traits, body measures and general type characteristics were adjusted by the equation with fixed effect of Herd-Year of type classification, quadratic regression on the number of days between calvings, and type classification and linear regression on age at the first calving. Cows were divided on the basis of the adjusted scoring of traits or characteristics into five classes.

(c) The length of herd life (HL) or production life (PL) of cows was adjusted by the equation with fixed effect of HYS and fixed effect of adjusted milk yield (see par (a).

The relationships between conformation traits and herd life and/or production life of cows were calculated by the model equation:

$$\mathrm{var}(e) = R = I\sigma_e^2 \quad E\begin{bmatrix} Y \\ e \end{bmatrix} = \begin{bmatrix} X\hat{o} \\ 0 \end{bmatrix}$$

$$[X'X][\hat{o}] = [X'Y]$$

where:

Y = the vector of functional HL or PL

$\hat{o}$ = the vector of fixed effect (alternative traits)

X = the incidence matrix of fixed effects

e = the residuum

Statistical analyses were performed using the multifactorial analysis of variance described by Rasch and Mašata (2006) and the procedures CORR and GLM of the statistical programme SAS (SAS Institute Inc., 2001).

RESULTS AND DISCUSSION

The relation between conformation traits and herd life (HL), and length of productive life (PL) were assessed by Pearson residual correlations given in Table 1. The length of herd life and productive life showed positive correlations with most linear type traits excluding rump angle, rear leg set-side view, udder depth, and teat length, which were negative. Similar results were published by Brotherstone and Hill (1991). However, these authors found positive correlations for udder depth. Negative correlations of central ligament and teat placement were found only with HL. The highest positive correlation coefficients were between HL and four general characteristics (r = 0.118–0.130), while in feet and legs the correlation was lower (r = 0.076). High positive correlations were also found for withers height and body length. For PL the correlation coefficients were higher in angularity, foot angle, fore udder attachment, teat placement, dairy character, feet and legs, and udder in comparison with HL. Vice versa, lower coefficients were found mainly in chest width, body depth, fore udder attachment, body capacity, rump and in all measures for the length of PL. Generally, our results are in agreement with correlations published by Vollema and Groen (1997), Vollema (1998), Strapák et al. (2005), and others.

Relations between conformation traits and longevity can be better demonstrated by the length of productive life depending on the level of classification in individual type traits. Table 2 contains PL in months according to the point scoring of linear type traits. In the case of angularity, PL increased with the number of points in linear scoring. This means that more angular cows had longer PL. This result is in discrepancy with the conclusions of other authors, who usually reported a nonlinear relationship between angularity and cow longevity. For example, Hamoen (2002) described the lowest culling rate in cows with a moderate scoring of

Table 1. Pearson correlation coefficients (r) between conformation traits and herd life (HL), and length of productive life (PL)

Trait	HL	PL
Angularity	0.094	0.126
Stature	0.087	0.063
Chest width	0.065	0.002
Body depth	0.040	0.003
Rump angle	–0.037	–0.061
Rump width	0.107	0.002
Rear legs set	–0.019	–0.075
Foot angle	0.048	0.060
Fore udder attachment	0.087	0.026
Rear udder height	0.076	0.083
Central ligament	–0.048	0.093
Udder depth	–0.055	–0.021
Front teat placement	–0.022	0.042
Teat length	–0.039	–0.058
Dairy character	0.109	0.145
Body capacity	0.130	0.063
Rump	0.128	0.099
Feet and legs	0.076	0.126
Udder	0.118	0.160
Withers height	0.132	0.079
Height in hips	0.088	0.065
Chest girth	0.093	0.008
Body length	0.136	0.049

Table 2. Effect of linear type trait score on the length of productive life

Trait	Level of type classification		Productive life in months		Statistical significance of differences
	class	*n*	LS mean	SE	
Angularity	1	5 988	28.99	0.098	1:2. 3. 4. 5
	2	9 410	29.99	0.078	2:3. 4. 5
	3	11 457	30.59	0.071	3:4. 5
	4	9 036	31.21	0.079	4:5
	5	5 598	32.33	0.101	
Stature	1	5 657	29.99	0.101	1:2. 4. 5
	2	8 979	31.01	0.080	2:3. 4. 5
	3	10 701	29.82	0.073	3:4. 5
	4	9 585	30.48	0.077	4:5
	5	6 367	31.98	0.094	
Chest width	1	4 997	29.73	0.108	1:2. 3. 4
	2	8 415	31.32	0.083	2:3. 4. 5
	3	13 052	30.80	0.067	3:4. 5
	4	9 965	30.56	0.076	4:5
	5	5 060	29.75	0.107	
Body depth	1	5 745	30.02	0.100	1:2. 3. 4. 5
	2	8 645	31.33	0.082	2:3. 4. 5
	3	11 836	30.56	0.070	3:5
	4	9 276	30.48	0.079	
	5	5 987	30.32	0.098	
Rump angle	1	5 296	30.29	0.104	1:2. 3. 4. 5
	2	9 650	31.51	0.077	2:3. 4. 5
	3	12 419	30.88	0.068	3:4. 5
	4	8 784	30.03	0.081	4:5
	5	5 340	29.50	0.104	
Rump width	1	6 112	30.06	0.097	1:2. 3. 4. 5
	2	9 357	31.13	0.079	2:3. 4. 5
	3	10 675	30.75	0.074	3:5
	4	9 545	30.60	0.078	4:5
	5	5 800	30.00	0.100	
Rear legs set	1	4 780	30.72	0.110	1:3. 5
	2	9 514	30.63	0.078	2:3. 5
	3	13 955	31.22	0.064	3:4. 5
	4	8 086	30.76	0.084	4:5
	5	5 154	28.45	0.105	
Foot angle	1	6 174	29.35	0.097	1:2. 3. 4. 5
	2	9 157	30.76	0.079	
	3	12 524	30.93	0.067	3:4
	4	8 232	30.67	0.084	
	5	5 402	30.81	0.103	

angularity. Our ascertained figures could be influenced by the dissimilarity of the Czech Holstein cow population. The dependence of PL on cow stature is not consistent. There is not a direct relationship between the stature of cows and their productive life. The effects of chest width and body depth are similar when the longest PL was found for cows with undersized scoring. Cows included in the second point level of classification reached more than 31.3 months of PL, while cows with minimal or maximal chest width scoring (class 1 or 5) had only 29.75 months of PL. Similar but lower differences were found in the body depth and rump width as well. Cows in the 2nd class of linear scoring of these traits had the significantly longest PL. Fore length of PL slightly angled rump (class 2) is the most suitable. The shortest PL (29.5 months) was found for cows with extremely sloped rumps (class 5). The longest PL (31.2 months) was in cows with regular rear legs set (class 3). Cows with sickled rear legs had the significantly lowest PL (28.5 months). There are no significant differences between straight legs (class 1 and 2) and slightly curved legs (class 4). Differences in PL according to the foot angle score were statistically significant ($P < 0.001$) only between class 1, i.e. cows with low foot angle, and

Table 3. Effect of linear udder trait score on the length of productive life

Trait	Level of type classification		Productive life in months		Statistical significance of differences
	class	*n*	LS mean	SE	
Fore udder attachment	1	7 929	30.28	0.085	1:3. 4
	2	8 499	30.19	0.083	2:3. 4. 5
	3	11 502	30.84	0.071	3:4. 5
	4	8 034	31.08	0.085	4:5
	5	5 525	30.45	0.102	
Rear udder attachment	1	6 188	29.31	0.097	1:2. 3. 4. 5
	2	9 103	30.40	0.080	2:3. 4. 5
	3	10 742	30.76	0.073	3:4. 5
	4	8 935	31.00	0.080	4:5
	5	6 521	31.25	0.094	
Central ligament	1	5 403	28.60	0.103	1:2. 3. 4. 5
	2	9 056	30.40	0.080	2:3. 4. 5
	3	12 507	30.88	0.068	3:4. 5
	4	8 706	31.14	0.081	4: 5
	5	5 817	31.30	0.099	
Udder depth	1	7 273	30.82	0.089	1:2. 3. 4. 5
	2	9 420	31.35	0.078	2:3. 4. 5
	3	11 707	30.30	0.070	
	4	7 616	30.09	0.087	
	5	5 473	30.31	0.103	
Front teat placement	1	5 398	30.12	0.104	1:2. 3. 4. 5
	2	9 711	30.43	0.077	2:4. 5
	3	11 732	30.41	0.070	3:4. 5
	4	8 643	30.94	0.082	
	5	6 005	31.15	0.098	
Teat length	1	5 447	30.86	0.103	1:2. 3. 4. 5
	2	8 499	30.58	0.082	2:3. 4. 5
	3	13 912	31.51	0.064	3:4. 5
	4	8 778	29.86	0.081	4:5
	5	4 853	29.01	0.109	

all other classes. Similar results were reported by Boetcher et al. (1997), who concluded that most of the body traits had slightly positive relationships with herd life, indicating that larger cows lived longer. However, body depth had a slightly negative relationship with some longevity traits.

The effects of udder linear traits are shown in Table 3. The longest PL was found for cows with above-average fore udder attachment (class 4), with highest rear udder attachment (class 5), and with deepest central ligament (class 5). In the case of udder depth, cows with moderately deep udders showed the longest PL. This finding differs from Hamoen (2002), who described the lowest culling rate for cows scored from 5 to 7 points corresponding to our scoring class 3 or 4. There is an early linear dependence between PL and the front teat placement classification when PL is extended with the scoring level. The significantly best PL was found for cows with moderate teat length (class 3). Cows with too long teats showed the lowest PL in comparison with the other classes ($P < 0.001$).

A direct proportion between the number of points and length of PL was shown in all five general characteristics of cow conformation (Table 4). Boetcher et al. (1997) concluded that dairy character was negatively related to longevity after adjustment for production. This is consistent with the results of other authors (Dekkers, 1993; Hamoen, 2002). On the contrary, Vollema (1998) reported positive relationships between dairy character and longevity traits as published by many researchers. Generally, there is a linear relationship between general characteristics or final score and longevity as found by Short and Lawlor (1992), Vollema (1998), and others.

Table 4. Effect of the general type characteristic score on the length of productive life

Trait	Level of type classification		Productive life in months		Statistical significance of differences
	class	*n*	LS mean	SE	
Dairy character	1	4 654	28.93	0.110	1:2. 3. 4. 5
	2	7 787	29.92	0.085	2:3. 4. 5
	3	14 271	30.16	0.063	3:4. 5
	4	8 083	31.12	0.084	4:5
	5	6 694	32.81	0.092	
Body capacity	1	5 555	29.73	0.102	1:2. 3. 4. 5
	2	9 781	30.44	0.077	2:4. 5
	3	10 270	30.54	0.075	3:4. 5
	4	9 917	30.78	0.076	4:5
	5	5 966	31.43	0.098	
Rump	1	5 426	28.98	0.103	1:2. 3. 4. 5
	2	9 287	30.20	0.079	2:3. 4. 5
	3	11 589	30.77	0.070	3:4. 5
	4	10 444	31.25	0.074	
	5	4 743	31.32	0.110	
Feet and legs	1	5 696	28.70	0.100	1:2. 3. 4. 5
	2	9 125	29.75	0.079	2:3. 4. 5
	3	13 535	31.08	0.065	3:5
	4	7 753	31.29	0.086	4:5
	5	5 380	31.79	0.103	
Udder	1	5 675	28.85	0.100	1:2. 3. 4. 5
	2	8 970	29.90	0.079	2:3. 4. 5
	3	11 219	30.43	0.071	3:4. 5
	4	9 771	30.90	0.076	4:5
	5	5 854	31.13	0.098	

CONCLUSION

The relationships between most of the conformation traits and analysed longevity parameters were significant. Some results of the assessment show that selection and mating focused on the functional type improvement of cows as done by breeders can be efficient in herd lifetime profitability. Ascertained results can be used as a tool for breeding schemes in dairy herds, and partial results can be applied in future research and breeding value estimation of longevity traits in the Czech Republic.

Acknowledgement

We thank Mrs. Lois Russell for editorial help with the manuscript.

REFERENCES

Boetttcher P.L., Jairath L.K., Koots K.R., Dekkers J.C.M. (1997): Effects of interactions between type and milk production on survival traits of Canadian Holsteins. J. Dairy Sci., *80*, 2984–2995.

Bouška J., Vacek M., Štípková M., Němec A. (2006): The relationship between linear type traits and stayability of Czech Fleckvieh cows. Czech J. Anim. Sci., *51*, 299–304.

Brotherstone S., Hill W.G. (1991): Dairy herd life in relation to linear type traits and production > 1. Phenotypic and genetic analyses in pedigree type classified herds. Anim. Prod., *53*, 279–287.

Cruickshank J., Weigel K.A., Dentine M.R., Kirkpatrick B.W. (2002): Indirect prediction of herd life in Guernsey dairy cattle. J. Dairy Sci., *85*, 1307–1313.

Dekkers J.C.M. (1993): Theoretical basis for genetic parameters of herd life and effects on response of selection. J. Dairy Sci., *76*, 1433–1443.

Essl A. (1998): Longevity in dairy cattle breeding: A review. Livest. Prod. Sci., *57*, 79–89.

Hamoen A. (2002): On the way to a functional cow. NRS presentation, June 2002, Arnhem, Netherlands.

Mark T. (2004): Applied genetic evaluation for production and functional traits in dairy cattle. J. Dairy Sci., *87*, 2641–2652.

Rasch D., Mašata O. (2006): Methods of variance component estimation. Czech J. Anim. Sci., *51*, 227–235.

SAS Institute Inc. (2001): Release 8.2 (TS2MO) of the SAS® System for Microsoft® Windows®. SAS Institute Inc., Cary, NC.

Short T.H., Lawlor T.J. (1992): Genetic parameters of conformation traits, milk yield, herd life in Holsteins. J. Dairy Sci., *75*, 1987–1998.

Strapák P., Candrák J., Aumann J. (2005): Relationship between longevity and selected production, reproduction and type traits. Czech J. Anim. Sci., *50*, 1–6.

Tsuruta S., Misztal I., Lawlor T.J. (2005): Changing definition of productive life in US Holsteins: Effect on genetic correlations. J. Dairy Sci., *88*, 1156–1165.

Vollema A.R. (1998): Longevity of dairy cows: A review of genetic variances and covariances with conformation. Anim. Breed., *66* (Abstr.), 781–802.

Vollema A.R., Groen A.F. (1997): Genetic correlations between longevity and conformation traits in an upgrading dairy cattle population. J. Dairy Sci., *81*, 3006–3014.

Vukasinovic N., Moll J., Künzi N. (1994): Analysis of type traits as predictor of longevity in Swiss brown cattle: Genetic parameters and sire evaluation. 45th EAAP Annual Meet., Edinburgh.

Vukasinovic N., Schleppi Y., Künzi N. (2002): Using conformation traits to improve reliability of genetic evaluation for herd life based on survival analysis. J. Dairy Sci., *85*, 1556–1562.

Received: 2006–01–20
Accepted after corrections: 2006–04–06

Corresponding Author

Ing. Mojmír Vacek, CSc., Research Institute of Animal Production, Přátelství 815, P.O. Box 1, 104 01 Prague 114-Uhříněves, Czech Republic
Tel. +420 267 009 591, fax +420 267 711 448, e-mail: vacek.mojmir@vuzv.cz